Intermodal Transportation

FIELD TECHNICIAN TRAINING

Study Guide

January 2016

ATTI Field Study Guide

ARIZ 103b
Sampling Bituminous Materials

SIZE OF SAMPLES	Section
1. A minimum of **1 gal.** for **Asphalt Binder**	2.1
2. A minimum of **two ½ gal. containers** per sample of **Emulsions**.	2.2
CONTAINERS	
3. Containers for Asphalt Binder shall be double friction top cans.	3.1
4. Containers for Emulsions shall be wide mouth containers made of plastic.	3.2
PROTECTION AND PRESERVATION OF SAMPLES	
5. Containers shall be **new, clean** and the top and container shall fit together tightly.	4.1
6. **Immediately** after filling, the container shall be **tightly sealed**.	4.2
7. If needed clean the container with a clean dry cloth, **do not use solvents**.	4.3
8. Protect Emulsions from **freezing**.	4.4
9. **Avoid transferring** samples from one container to another.	4.5
10. **Identify** containers using sample **tags** attached securely to the **side**, and clearly identify the container on the **side** using **permanent marker**.	4.6
PROCEDURE	
11. Samples of **Asphalt Binder** shall be taken at the **last** possible point before it is introduced into the **hot plant**. Usually from a spigot or faucet on the circulation line.	5.1
12. Bituminous materials applied to **pavement surfaces** shall be sampled from the **distributor truck** at the project.	5.2
13. Identify the **side** of a new container of appropriate size with any pertinent information.	5.3
14. Draw off and discard a minimum of **one gallon** of material before obtaining the sample.	5.4
15. Draw off the minimum amount of material required for the type of material being sampled, from the valve. Fill the container to no closer than **one inch** from the top.	5.5
16. Immediately **seal** the clearly identified container tightly and securely.	5.6

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ARIZ 104e
Sampling Bituminous Mixtures

SAMPLING ASPHALT CONCRETE and ASPHALTIC CONCRETE (ASPHALT-RUBBER)	Section
1. Asphaltic Concrete **(AC)** and Asphaltic Concrete (Asphalt-Rubber) **(ARAC)** shall be sampled **using the plate** as described in Subsections 2.4 through 2.6.	2.1
2. Asphaltic Concrete Friction Course **(ACFC)** and Asphaltic Concrete Friction Course (Asphalt-Rubber) **(AR-ACFC)** shall be sampled **at the plant** as described in Subsection 2.7.	2.2
3. For **(AC) and (ARAC)** place sample plate about **1** foot from the edge of the mat being laid.	2.4
4. Hold the plate in position while the paver passes over the plate by holding the wire down with your foot.	2.4
5. After the paver passes over the plate locate the plate by pulling up on the wire.	2.5
6. Using a square point shovel remove the material from the center of the plate making sure **not to remove the sluffed material** left in the resultant trench.	2.6
7. As an alternate to using a shovel use a template or “cookie cutter” and remove all the material within the template.	2.6 Note:

SAMPLING ASPHALT CONCRETE FRICTION COURSE (ACFC) or ASPHALT CONCRETEFRICTION COURSE (ASPHALT-RUBBER) (AR-ACFC)

8. An adequate amount of material is taken from the truck at the plant within **five** minutes of the loading of the truck.	2.7
9. Sample obtained from at least **3** random locations, approximately **12”** below the surface.	2.7
10. Combine and **protect the samples** to avoid the loss of heat during transport.	2.7

SAMPLING FINISHED PAVEMENT

1. Samples taken through the **complete thickness of the lift** with minimum disturbance of the sample.	3.1
12. Obtain sample by **coring** (preferred) or by the use of a **saw, pick, or jackhammer**, or other suitable means.	3.3
13. Contain samples in **briquette form**, transport on **flat surface**, and **protect** from deformation or fracture.	3.4
14. Use **ice** to obtain and/or transport samples.	3.5

SAMPLING MISCELLANEOUS PLACEMENT OF ASPHALT

15. Sample from the **hauling vehicle** by random **shovelfuls**.	4.1

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ARIZ 105f
Sampling Soils and Aggregates

SAMPLING STOCKPILES		Section
1.	Place a wood or metal **shield** upslope from the sampling point.	2.2
2.	Remove **3-6 inches** of material from in front of the shield.	2.2
3.	With a square point shovel obtain **one shovelful** of material near the **top, middle and bottom** of the stockpile.	2.2
4.	Obtain **one** shovelful of material **per location**.	2.2
5.	Combine all samples.	2.2
6.	Samples are taken from **each quarter** of round stockpiles and from **every other section** of oblong stockpiles.	Fig. 1.
SAMPLING BINS		
7.	Allow sufficient material to pass, to **ensure uniformity** of material.	3.1
8.	Pass sampling device through the **entire cross-section** of material being discharged.	3.1
9.	Repeat as needed to obtain desired amount of material.	3.1
SAMPLING CONVEYOR BELTS		
10.	Stop the belt and place template on the belt.	4.1.2
11.	Remove all material from the template; use a **brush** to obtain all the fine aggregate.	4.1.2
SAMPLING FROM A WINDROW		
12.	Remove **sufficient** amount of material from the top of the windrow to obtain a representative sample. Sample is obtained from the **center** of the freshly exposed portion of the windrow.	5.1
13.	**One shovelful** of material is taken from each location.	5.1
14.	All samples are combined and placed in a container.	5.1
SAMPLING FROM A ROADWAY		
15.	**Three** samples taken with a shovel at **equal distance apart**, across the roadway.	6.1
16.	Sample taken to the **entire depth** of the lift being tested.	6.1
17.	Obtain **all material** from the hole and combine	6.1

ARIZ 225b (Appendix A)
Calibration of Proctor Molds

CALIBRATION	**Section**
1. Molds shall be calibrated at least **once a year** or sooner if there is reason to question the accuracy of the calibration.	1.1
2. Lightly **grease** the bottom of the mold (split molds grease edges of the split)	1.2
3. Attach mold to baseplate	1.3
4. Wipe off excess grease.	1.4
5. **Weigh** empty mold, baseplate, and glass plate to at least the **nearest 0.1 gram**.	1.5
6. Fill mold with **distilled** water at room temperature **77 ± 9°F**.	1.6
7. Record the temperature of the water to at least the **nearest 1°F**.	1.7
8. Remove air bubbles from the sides and bottom of the mold. Place a glass plate on the mold, eliminating any air bubbles.	1.8
9. Remove all water from the outside of the mold, baseplate and glass plate. **Weigh** the filled mold, baseplate and glass plate to at least the **nearest 0.1 gram**.	1.9

ARIZ 227c
Rock Correction Procedure

SCOPE **Section**

1. The rock correction procedure shall **not** be used when the material consists of volcanic cinders or light weight **porous** material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is **greater than 4.0%**. 1. (a)

2. The rock correction procedure **shall not be used** when the percent rock retained on the No. 4 for **Method A** is less than **10%** or greater than **50%** (greater than **60%** in the case of an aggregate base material); or when the percent rock retained on the 3/4 inch sieve for Alternate **Method D** is less than **10%** or greater than **50%**. 1. (b)

ROCK CORRECTED MAXIMUM DRY DENSITY

3. $$\mathrm{CMD} = \frac{[(100 - \mathrm{PR}) \times (\mathrm{MD})\ ] + [(56.2) \times (\mathrm{PR}) \times (\mathrm{SG})\ ]}{100}$$

Where: CMD = Corrected maximum dry density of the total sample containing "PR" percent coarse rock particles, lbs./cu. ft.

PR = "PR4", percent rock retained on the No. 4 sieve for Method A; or "PR¾" percent rock retained on the 3/4 inch sieve for Alternate Method D.

MD = Maximum dry density from **Proctor** (Method A for plus No.4; or Alternate Method D for plus 3/4 inch), lbs./cu. ft.

SG = Bulk O.D Specific Gravity of the coarse aggregate.

3.

ROCK CORRECTED OPTIMUM MOISTURE CONTENT

4. $$\mathrm{COM} = \frac{[(\mathrm{OM}) \times (100 - \mathrm{PR})\ ] + \mathrm{PR}}{100}$$

Where: COM = Corrected optimum moisture content for the total sample.

OM = Optimum moisture content for Pass No. 4 (Method A) or pass 3/4 inch material (Alternate Method D).

PR = "PR4", % rock retained on the No.4 sieve for Method *Ai* or "PR¾, "% rock retained on the 3/4 inch sieve for Alternate Method D.

4.

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ARIZ 229a
Calibration of Standard Sand and Sand Cone

PROCEDURE	Section
1. Fill apparatus with the sand to be standardized.	3.(a)
2. Weigh the empty **0.075 cu. ft. mold** (6” proctor mold) to at least the nearest **1.0 grams**.	3. (b)
3. Set mold in a pan to catch excess sand.	3. (c)
4. Invert the apparatus and place the funnel directly over the mold.	3. (d)
5. Open the valve and let the sand flow **until it stops**.	3. (e)
6. Assure there are **no vibrations** at this time.	3. (e)
7. Close the valve and carefully remove the apparatus from the mold.	3. (f)
8. Strike off the sand in the **least** strokes as possible until the sand is **level** with the top of the mold.	3. (g)
9. Tap the side of the mold and weigh to at least the nearest **1.0 gram**.	3. (g)
10. Repeat steps (a) through (g) **two more times** for an average of three.	3. (h)
11. Refill the apparatus and weigh it to at least the nearest **1.0 grams**.	3. (i)
12. Place the baseplate in a flat bottom pan.	3. (j)
13. Invert the apparatus and place it on the baseplate, **matching up the marks** on the funnel and baseplate.	3. (k)
14. Open the valve and let the sand flow **until it stops**	3. (l)
15. Assure there are **no vibrations** at this time.	3. (l)
16. Close the valve and carefully remove the apparatus from the baseplate. Weigh the apparatus to at least the nearest **1.0 grams**.	3. (m)
17. Repeat steps (i) through (j) **two more times** for an average of three.	3. (n)

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ARIZ 230a
Field Density by the Sand Cone Method

PREPARATION OF TEST SITE	**Section**
1. Clean away all loose material from an area of about **3 feet square** where the test is being done. Get below the depth of any sheep's foot roller imprints.	3. (a)
2. Level the test spot a little larger than the baseplate. Then place the baseplate on the spot to be tested.	3. (b)
PROCEDURE	
3. Using a hammer and chisel if necessary, dig a hole about the **same diameter** of the hole in the baseplate. Be careful not deform the hole or disturb the surrounding material in the hole.	4. (a)
4. The hole should be dug to a depth of usually **6 to 8 inches**, the **depth of the lift**, or according to **Table 1**. Dig the hole as **quick** as possible.	4. (a)
5. As the hole is being dug, remove **all the material** from the hole and put it into a suitable container and keep it **covered** to prevent any loss of moisture.	4. (a)
6. Weigh the apparatus to at least the **nearest gram**, and place it on the hole with the cone down. Be sure to line up the **match marks** on the baseplate and the cone.	4. (b)
7. Make sure there is **no vibration** in the area while performing the sand cone procedure.	4. (c)
8. Open the valve and let the sand flow freely **until it stops**. Be careful **not to jar the apparatus** at this time. When the sand stops flowing, close the valve and weigh the apparatus to the **nearest gram**.	4. (d,e)
REFERENCE TO METHOD 'A' PROCTOR	
9. Weigh the material from the hole to the **nearest gram**.	5. (a)
10. Screen the material from the hole over a **3" and #4 sieve**.	5. (b)
11. Clean fines from the rock using a **brush**	5. (c)
12. If any rock is retained on the **3" sieve**, the sand cone density is **not determinable**.	5. (d)
13. Weigh and record the material retained on the **#4 sieve**.	5. (e)
14. Immediately obtain a **moisture** sample from the material **passing** the **#4 sieve**.	5. (f)
15. Determine the **percent of rock**.	5. (g)
16. If the rock content is greater than **50%** (or **60%** in the case of AB) the density is **not determinable** due to excess rock.	5. (h)

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ARIZ 232b/246b
One Point Proctor (Method A & D)

PROCEDURE	**Section**
1 Weigh a sample of about **2500** grams of pass **#4** for (**method "A"**), or about **5000** grams of pass **¾"** for (**method "D"**)	4.
2. Thoroughly mix the sample with water to bring it to **slightly less than** its optimum moisture content.	5. (a)
3. Place the sample in a pre-weighed **4" (method "A")** or **6" (method "D")** in a mold and collar **three** equal layers.	5. (b)
4. Compact each layer with **25 (method "A")** or **56 (method "D")** uniformly distributed blows. Drop the rammer vertically and freely from a height of **12"**.	5. (b)
5. While compacting the sample, **cover** the remaining sample in the pan with a damp cloth.	5. (b)
6. Total depth of compacted sample is about **5 inches**.	5. (b)
7. Carefully remove the extension collar. Trim the sample **even** with the top of the mold. **Fill voids** with fines and smooth off even with top of the mold.	5. (d)
8. Weigh the mold and sample to the **nearest gram**.	5. (d)
9. Remove sample from mold and slice vertically through the **center**.	5. (e)
10. Obtain a minimum of **300 gram (method "A")** or **600 gram (method "D")** sample from the full length and width of **one of the cut faces**.	5. (e)
11. Weigh **Moisture** sample to the **nearest 0.1 gram**, dry to **constant weight** at 230°F. Record the percent moisture to the nearest **0.1%**.	5. (e)
12. For the **Speedy** moisture tester, a representative sample of **pass #4** shall be utilized and tested.	5. (e)
13. For (**Method "D")** the **Speedy** results must be **adjusted** for material retained on the **#4 sieve**.	5.10

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ARIZ 235
Nuclear Density and Moisture Content of Soils and Aggregates

GAUGE STABILITY CHECK	Section
1. Place the reference standard block on a flat, hard, dry surface. At least **24”** from a vertical projection, **15’** from any large objects, and **50’** from another nuclear gauge.	4. (a)
2. **Seat gauge** on standard block in accordance with the gauge operation manual.	4. (b)
3. Remove the lock from the source handle.	4. (c)
4. Turn on gauge and **warm up** in accordance with the gauge operation manual.	4. (d)
5. Take a standard **moisture** count and a standard **density** count.	4. (e)
6. **Record** the standard moisture count and a standard density count in the log book.	4. (f)
7. Determine if the standard counts are **within the limits for normal operation** in accordance with the gauge operation manual.	4. (h)
SITE PREPARATION	
8. Select a location for the test at random, at least **24”** from a vertical projection, **15’** from any large objects, and **50’** from another nuclear gauge.	5. (a)
9. **Remove** all loose, disturbed, and excess material as necessary to reach the top of the compacted lift to be tested.	5. (b)
10. Prepare an area large enough for the gauge by using the scraper plate. Smooth the test area by removing loose stones to obtain **maximum contact** between the gauge and surface of test site.	5. (b)
11. Use native fines, which pass a **#10 sieve**, or fine dry sand to fill **voids only**, and level the excess with the scraper plate.	5. (c)
OBTAINING NUCLEAR MOISTURE AND DENSITY COUNTS	
12. Securely hold the scraper plate in position while driving the drill rod **at least 2” deeper** then the depth to be tested.	6. (d)
13. Remove the drill rod, and scraper plate.	6. (e,f)
14. Place the gauge over the hole and **extend the probe** into the hole to the depth to be tested.	6. (g)
15. When the probe is extended to the testing depth, **pull the gauge** toward the scaler or readout end of the gauge.	6. (h)
16. Take a density and moisture count for a minimum of **one minute**.	6. (i)
17. After the count period record the following data, Wet Density (**WD**), Dry Density (**DD**), Moisture (**M**), Percent Moisture (**%M**), Moisture Counts (**MC**), and Density Counts (**DC**).	6. (j)
18. If the material being tested is **not homogeneous**, or has large **variations** in rock content, it may be necessary to turn the gauge **90°**and obtain another one minute count. **Compare** the two moisture and wet density readings, if they differ by **5% or less then average** the two readings. If they differ by **more than 5%** the gauge should be moved to a **new test site**.	6. (k)

ARIZ 235 (continued)
Nuclear Density and Moisture Content of Soils and Aggregates

PROCTOR DENSITY ROCK CORRECTION **Section**

19. If it appears at least **10%** of material will be retained on a **#4** (Method A) or **¾"** (Method D), **excavate** the area tested (the **footprint of the gauge**) to the depth of the test (the **depth of the probe**). 7. (b)

20. Obtain a minimum **3000 gram** (7 pound) sample of the excavated material reduced by **AASHTO T248, Quartering**. Sieve material over a 3” sieve to determine the presence of any oversize rock. If any **oversize rock is present**, report the test is not determinable due to oversize rock. 7. (c,d)

21. If **no oversize rock is present**, sieve material over a **#4 or ¾" sieve** to determine the Percent of Rock (PR). If the material has **10 to 50** percent (**10 to 60 percent if AB**) on the **#4** (Method A) or **10 to 50** percent on the **¾"** (Method D), the max **proctor density** will require a **Rock Correction**. 7. (c,f)

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ARIZ 412b
Density of Compacted Bituminous Mixtures – Nuclear Method

GAUGE STABILITY CHECK	**Section**
1. Place the reference standard block on a flat, hard, dry surface. At least **15’** from any large objects, and **50’** from another nuclear gauge.	3. (a)
2. **Seat gauge** on standard block in accordance with the gauge operation manual.	3. (b)
3. Remove the lock from the source handle.	3. (c)
4. Turn on gauge and **warm up** in accordance with the gauge operation manual.	3. (d)
5. Take a standard **moisture** count and a standard **density** count.	3. (e)
6. **Record** the standard moisture count and a standard density count in the log book.	3. (f)
7. Determine if the standard counts are **within the limits for normal operation** in accordance with the gauge operation manual.	3. (h)
PROCEDURE	
8. **Brush** away any loose particles from the surface of the test site.	4. (b)
9. Use not more than **one pound** of dry minus **#10** sand, and spread it over the test site.	4. (b)
10. Using a straightedge scrape away any **excess** sand so the sand is visible over the majority of the surface.	4. (b)
11. Place the gauge on the test site, check for **full contact** and take a **one minute** reading. Record the **wet density** to the nearest **0.1 lb. per cu./ft**.	4. (a)
12. Rotate the gauge **180°** in the same footprint and take another **one minute** reading. Record the wet density to the nearest **0.1 lb. per cu./ft**. The two one minute reading are then **averaged** and recorded to the nearest 0.1 lb. per cu./ft.	4. (a)

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AASHTO T217-14
Speedy Moisture Tester

PROCEDURE	**Section**
1. Place **three** scoops of calcium carbide into the cap of the “Speedy Moisture Tester”.	5.1
2. Prevent the Calcium Chloride from coming into **direct contact with water**.	Note 4
3. Carefully place the two **1.25” steel balls** in the tester.	5.2
4. **Weigh** a sample on the scale and place it in the body of the tester.	5.2
5. **Alternatively**, the reagent may be placed in the body and the sample in the cap.	5.2
6. With the tester in a **horizontal position** insert the cap in the tester and **seal the cap**. Be **careful** no calcium carbide comes in contact with the sample until the tester is sealed.	5.3
7. Raise the test in a **vertical** position so the sample and reagent will fall into the tester.	5.4
8. Shake the tester in a **rotating motion** in a horizontal position for **60 seconds** for granular material and up to **180 seconds** for other soils.	5.5
9. Time should be permitted to allow **dissipation of heat** generated by the chemical reaction.	Note 8
10. When the **needle stops** moving read the dial while holding the tester in a **horizontal** position at **eye level**.	5.6
11. Empty the tester into a pan, **inspect** for lumps. If the sample is not **completely pulverized** repeat the test with a new moisture sample. **Clean** the tester before reusing.	5.8
12. **Convert** the dial reading to dry mass using the chart.	5.9

AASHTO T 248-14
Reducing Samples of Aggregate to Testing Size

METHOD B-QUARTERING	**Section**
1. Place sample on a **clean hard level surface**.	10.1.1
2. Turn material over **three times to mix**. Form a **conical pile** on the last turning.	10.1.1
3. Flatten pile using the shovel so the **diameter is 4 to 8 times** the thickness.	10.1.1
4. Divide the sample into **four equal portions**, and remove **opposite** quarters using a shovel or trowel. **Remove fines** with a brush.	10.1.1
5. For **uneven surfaces** place the sample on a **mat** and mix at least **four times** by **rolling** using the mat.	10.1.2
6. Flatten pile using the shovel so the **diameter is 4 to 8 times** the thickness.	10.1.2
7. Divide the sample into four equal sections **using a stick**.	10.1.2
8. Remove opposite quarters. Use a brush to **remove the fines**.	10.1.2

ADOT
Intermodal Transportation

Field Technician Review Class

Practice Calculations

Calibration of Proctor Mold

✔ Four Inch Mold ______Six Inch Mold

Mold I. D. #: X

Temperature of Water used for Calibration: 77

Unit Weight of Water:____________________lb. / cu. Ft.

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled With Water, and Glass Plate (grams)	Weight of Water to fill Mold (grams)
4439.5	5375.8	

$$\begin{bmatrix}\text{Volume of} \\ \text{Mold} \\ \text{(cu. ft.)}\end{bmatrix} = \frac{\text{Weight of Water to Fill Mold (grams)}}{\begin{bmatrix}\text{Unit Weight} \\ \text{of Water} \\ \text{(lb. / cu. ft.)}\end{bmatrix} \times [453.6\ \text{(grams / lb.)}]}$$

$$= \frac{(\qquad\qquad)}{(\qquad\qquad) \times (453.6)} = \underline{\qquad\quad}\ \text{cu. Ft.}$$

Remarks:____

Calibration Date:______________________________________

Test Operator:____

Supervisor and Date:___________________________________

Calibration Expiration Date:____________________________

APPENDIX A - (Continued)

Temperature	Unit Weight of Water
Temp °F	**lbs/cu. Ft.**
68	62.315
69	62.308
70	62.301
71	62.293
72	62.285
73	62.277
74	62.269
75	62.261
76	62.252
77	62.243
78	62.234
79	62.225
80	62.216
81	62.206
82	62.196
83	62.186
84	62.176
85	62.166
86	62.155

Calibration of Proctor Mold

______Four Inch Mold ✔______Six Inch Mold

Mold I. D. #: Z

Temperature of Water used for Calibration: 71

Unit Weight of Water:______________________lb. / cu. Ft.

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled With Water, and Glass Plate (grams)	Weight of Water to fill Mold (grams)
7103.5	9225.1	

$$\begin{bmatrix}\text{Volume of}\\ \text{Mold}\\ \text{(cu. ft.)}\end{bmatrix} = \frac{\text{Weight of Water to Fill Mold (grams)}}{\begin{bmatrix}\text{Unit Weight}\\ \text{of Water}\\ \text{(lb. / cu. ft.)}\end{bmatrix} \times [453.6\ \text{(grams / lb.)}]}$$

$$= \frac{(\qquad\qquad)}{(\qquad\qquad) \times (453.6)} = \underline{\qquad\quad}\ \text{cu. Ft.}$$

Remarks:____

Calibration Date:______________________________________

Test Operator:____

Supervisor and Date:___________________________________

Calibration Expiration Date:____________________________

CALIBRATION OF DENSITY SAND AND SAND CONE APPARATUS
ARIZ 229
(A Modification of AASHTO T 191)

Date of Calibration:______________Test Operator:______________________________

I. D. No. of Mold used in calibration: ______________________________________

Volume of Mold used in calibration: ______________________________________

Identification of Sand: ____

Identification of Sand Cone Apparatus: ____________________________________

Trial No.	Wt. of Baseplate And Empty Mold (grams)	Wt. of Baseplate and Mold Filled with Sand (grams)	Wt. of Sand to Fill Mold (grams)
1	6573	9595	
2	6573	9597	
3	6573	9591	

Average Weight of Sand to Fill Mold = _________grams

$$\text{Density of Sand, } D_s = \frac{\text{Average Weight of Sand to Fill Mold}}{(453.6 \text{ grams / lb.}) \times (\text{Volume of Mold})}$$

$$= \frac{\qquad\qquad}{(453.6) \times (\qquad\qquad)} = \frac{\qquad}{\qquad} = \text{lb./ft.}^3$$

Trial No.	Initial Wt. of Apparatus (grams)	Final Wt. of Apparatus (grams)	Wt. of Sand to Fill Funnel and Baseplate (grams)
1	6242	4723	
2	6236	4731	
3	6237	4730	

Average Weight of Sand to Fill Funnel and Baseplate = __________grams

$$\text{Volume of Funnel and Baseplate, } V_{fb} = \frac{\text{Average Weight of Sand to Fill Funnel and Baseplate}}{(453.6 \text{ grams / lb.}) \times (\text{Density of Sand})}$$

$$= \frac{\qquad\qquad}{(453.6) \times (\qquad\qquad)} = \frac{\qquad}{\qquad} = \text{ft.}^3$$

Remarks: ______ **$I = D_s \times V_{fb}$** ______________________________________

____

Supervisor and Date: ____

Calibration Expiration Date: ____

ARIZONA DEPARTMENT OF TRANSPORTATION
SAND CONE DENSITY (ARIZ 230)

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %
		AB					

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO DAY YEAR	TIME (MILITARY TIME)
				:

SAMPLED FROM	LIFT NO.	RDWY	STATION (IF MILEPOST, INPUT DECIMAL)
			+

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER

REMARKS

A. TOTAL WET WEIGHT OF MATERIAL FROM THE HOLE	10.11	LB.
B. WET WEIGHT OF MATERIAL RETAINED ON THE #4 SIEVE	4.88	LB.
C. WET WEIGHT OF MATERIAL PASSING THE #4 SIEVE (A-B)	.	LB.
D. MOISTURE OF THE MATERIAL PASSING THE #4 SIEVE	8.6	%
E. MOIST. CORRECTED FOR MATERIAL RETAINED ON THE #4 SIEVE	.	%
F. WEIGHT OF SAND & APPARATUS BEFORE FILLING HOLE	14.17	LB.
G. WEIGHT OF SAND & APPARATUS AFTER FILLING HOLE	4.47	LB.
H. WEIGHT OF SAND TO FILL HOLE AND CONE (F-G)	.	LB.
I. WEIGHT OF SAND TO FILL CONE AND BASE PLATE	.	LB.
J. WEIGHT OF SAND TO FILL HOLE (H-I)	.	LB.
K. DENSITY OF SAND	.	PCF
L. VOLUME OF HOLE $\left(\frac{J}{K}\right)$	.	CF
M. WET DENSITY = $\left(\frac{A}{L}\right)$	.	PCF
N. DRY DENSITY = $\left(\frac{M}{100+E}\right) \times 100$	.	PCF
COMPACTION = $\left(\frac{N}{R}\right) \times 100$ OR $\left(\frac{N}{T}\right) \times 100$		%
COMPACTION SPECIFICATION	100	%

PROCTOR DENSITY

PROCTOR NUMBER		
PROCTOR METHOD (A, C, D, OR 1)	A	
O. SPECIFIC GRAVITY OF RETAINED #4	2.528	
P. ABSORPTION OF RETAINED #4	0.87	%
Q. OPTIMUM MOISTURE	10.1	%
R. MAXIMUM DRY DENSITY	127.8	PCF

CORRECTION FOR RETAINED #4 (METHOD A OR ONE-POINT ONLY)

S. CORRECTED OPTIMUM MOISTURE	.	%
T. CORRECTED MAXIMUM DRY DENSITY	.	PCF

a. RETAINED ON #4 = $\left(\frac{B}{A}\right) \times 100$		%

IF RET. ON #4 IS MORE THAN 50% (60% IF AB), GO NO FURTHER.

FOR METHOD A OR ONE POINT ONLY

$$E = \frac{[D\ (100 - a)] + a}{100}$$

ONE POINT PROCTOR (ARIZ 232)

b. WEIGHT OF MOLD & SOIL	16.12	LB.
c. WEIGHT OF MOLD	11.63	LB.
d. WEIGHT OF COMPACTED SOIL (b-c)	.	LB.
e. VOLUME OF MOLD	.	CF
f. WET DENSITY (d / e)	.	PCF
g. MOISTURE CONTENT	8.1	%
FAMILY OF CURVES IDENTIFICATION	&	
Q. OPTIMUM MOISTURE	.	%
R. MAXIMUM DRY DENSITY	.	PCF

TEST OPERATOR AND DATE

RESIDENT ENGINEER, PROJECT SUPERVISOR, OR LABMAN AND DATE

FOR METHOD A OR ONE POINT ONLY

$$S = \frac{[Q\,(100 - a)] + a}{100}$$

$$T = \frac{[R\,(100 - a)] + [(56.2)(a)(O)]}{100}$$

Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

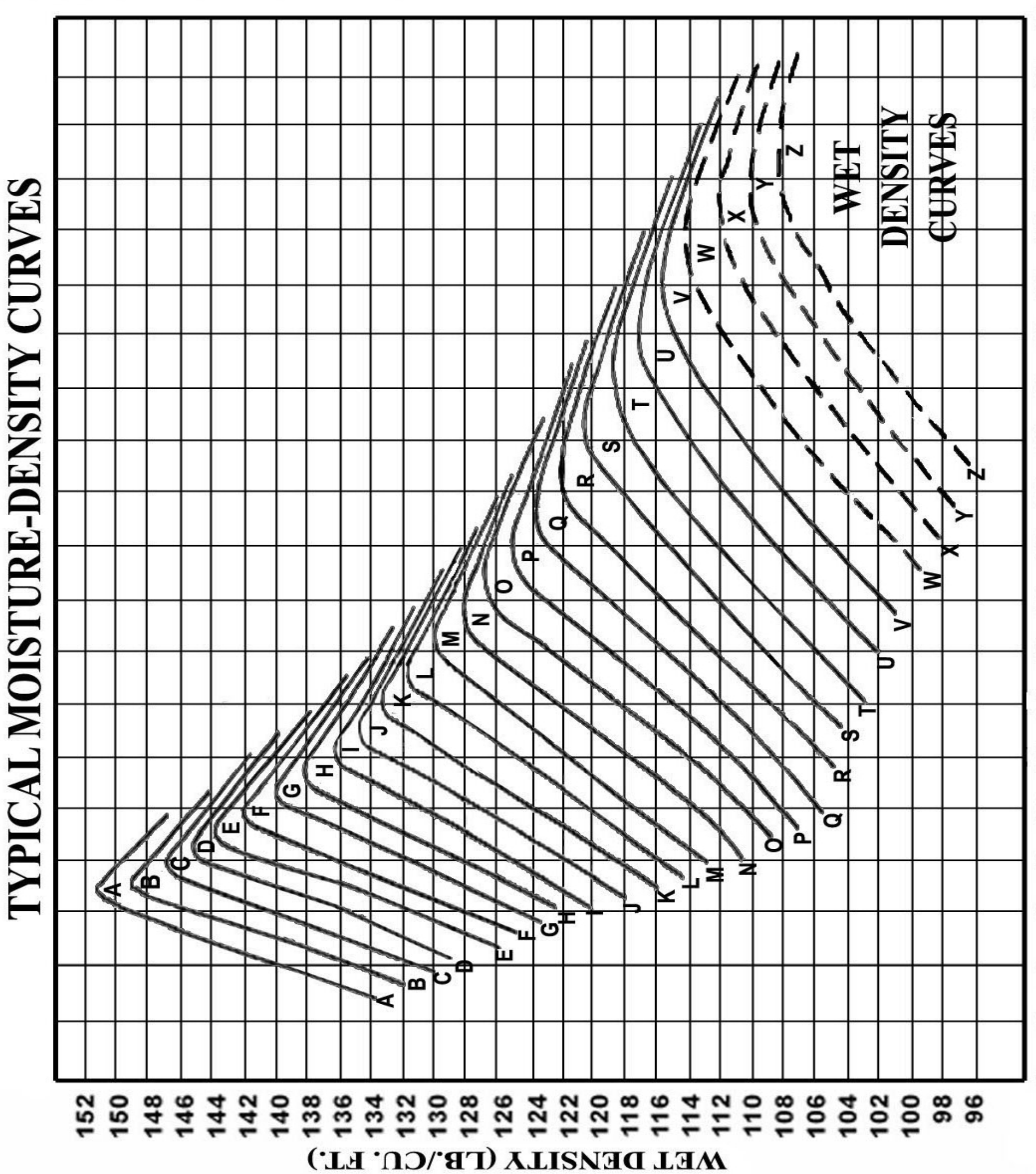

FIGURE 2

A	**141.8**	**6.6**	F	**129.3**	**9.7**	K	**117.0**	**13.5**	P	**104.7**	**19.2**	U	**92.1**	**25.8**
10%	141.5	6.7	10%	129.0	9.8	10%	116.8	13.6	10%	104.5	19.3	10%	91.9	26.0
20%	141.3	6.7	20%	128.8	9.9	20%	116.5	13.7	20%	104.2	19.4	20%	91.7	26.1
30%	141.0	6.8	30%	128.5	9.9	30%	116.3	13.8	30%	104.0	19.5	30%	91.4	26.3
40%	140.7	6.8	40%	128.2	10.0	40%	116.0	13.9	40%	103.8	19.6	40%	91.2	26.4
50%	140.5	6.9	50%	128.0	10.1	50%	115.8	14.1	50%	103.6	19.8	50%	91.0	26.6
60%	140.2	7.0	60%	127.7	10.2	60%	115.6	14.2	60%	103.3	19.9	60%	90.8	26.8
70%	139.9	7.0	70%	127.4	10.3	70%	115.3	14.3	70%	103.1	20.0	70%	90.6	26.9
80%	139.6	7.1	80%	127.1	10.3	80%	115.1	14.4	80%	102.9	20.1	80%	90.3	27.1
90%	139.4	7.1	90%	126.9	10.4	90%	114.8	14.5	90%	102.6	20.2	90%	90.1	27.2
B	**139.1**	**7.2**	G	**126.6**	**10.5**	L	**114.6**	**14.6**	Q	**102.4**	**20.3**	V	**89.9**	**27.4**
10%	138.8	7.3	10%	126.4	10.6	10%	114.3	14.7	10%	102.2	20.4	10%	89.7	27.6
20%	138.5	7.3	20%	126.1	10.6	20%	114.1	14.8	20%	101.9	20.5	20%	89.4	27.8
30%	138.3	7.4	30%	125.9	10.7	30%	113.8	15.0	30%	101.7	20.7	30%	89.2	28.0
40%	138.0	7.5	40%	125.6	10.8	40%	113.6	15.1	40%	101.4	20.8	40%	88.9	28.2
50%	137.7	7.6	50%	125.4	10.9	50%	113.3	15.2	50%	101.2	20.9	50%	88.7	28.5
60%	137.4	7.6	60%	125.2	10.9	60%	113.0	15.3	60%	100.9	21.0	60%	88.5	28.7
70%	137.1	7.7	70%	124.9	11.0	70%	112.8	15.4	70%	100.7	21.1	70%	88.2	28.9
80%	136.9	7.8	80%	124.7	11.1	80%	112.5	15.6	80%	100.4	21.3	80%	88.0	29.1
90%	136.6	7.8	90%	124.4	11.1	90%	112.3	15.7	90%	100.2	21.4	90%	87.7	29.3
C	**136.3**	**7.9**	H	**124.2**	**11.2**	M	**112.0**	**15.8**	R	**99.9**	**21.5**	W	**87.5**	**29.5**
10%	136.1	8.0	10%	124.0	11.3	10%	111.8	15.9	10%	99.7	21.6	10%	87.3	29.6
20%	135.9	8.0	20%	123.7	11.3	20%	111.5	16.0	20%	99.4	21.7	20%	87.0	29.7
30%	135.6	8.1	30%	123.5	11.4	30%	111.3	16.1	30%	99.2	21.9	30%	86.8	29.8
40%	135.4	8.1	40%	123.2	11.5	40%	111.0	16.2	40%	98.9	22.0	40%	86.5	29.9
50%	135.2	8.2	50%	123.0	11.6	50%	110.8	16.4	50%	98.7	22.1	50%	86.3	30.0
60%	135.0	8.3	60%	122.7	11.6	60%	110.6	16.5	60%	98.4	22.2	60%	86.0	30.1
70%	134.8	8.3	70%	122.5	11.7	70%	110.3	16.6	70%	98.2	22.3	70%	85.8	30.2
80%	134.5	8.4	80%	122.2	11.8	80%	110.1	16.7	80%	97.9	22.5	80%	85.5	30.3
90%	134.3	8.4	90%	122.0	11.8	90%	109.8	16.8	90%	97.7	22.6	90%	85.3	30.4
D	**134.1**	**8.5**	I	**121.7**	**11.9**	N	**109.6**	**16.9**	S	**97.4**	**22.7**	X	**85.0**	**30.5**
10%	133.9	8.6	10%	121.5	12.0	10%	109.4	17.0	10%	97.1	22.9	10%	84.8	30.6
20%	133.7	8.6	20%	121.2	12.1	20%	109.1	17.1	20%	96.8	23.0	20%	84.6	30.7
30%	133.5	8.7	30%	121.0	12.1	30%	108.9	17.3	30%	96.6	23.2	30%	84.4	30.8
40%	133.3	8.7	40%	120.7	12.2	40%	108.6	17.4	40%	96.3	23.4	40%	84.2	30.9
50%	133.1	8.8	50%	120.5	12.3	50%	108.4	17.5	50%	96.0	23.6	50%	84.0	31.0
60%	132.8	8.8	60%	120.3	12.4	60%	108.1	17.6	60%	95.7	23.7	60%	83.8	31.1
70%	132.6	8.9	70%	120.0	12.5	70%	107.9	17.7	70%	95.4	23.9	70%	83.6	31.2
80%	132.4	8.9	80%	119.8	12.5	80%	107.6	17.9	80%	95.2	24.1	80%	83.4	31.3
90%	132.2	9.0	90%	119.5	12.6	90%	107.4	18.0	90%	94.9	24.2	90%	83.2	31.4
E	**132.0**	**9.0**	J	**119.3**	**12.7**	O	**107.1**	**18.1**	T	**94.6**	**24.4**	Y	**83.0**	**31.5**
10%	131.7	9.1	10%	119.1	12.8	10%	106.9	18.2	10%	94.4	24.5	10%	82.8	31.6
20%	131.5	9.1	20%	118.8	12.9	20%	106.6	18.3	20%	94.1	24.7	20%	82.6	31.7
30%	131.2	9.2	30%	118.6	12.9	30%	106.4	18.4	30%	93.9	24.8	30%	82.4	31.8
40%	130.9	9.3	40%	118.4	13.0	40%	106.1	18.5	40%	93.6	25.0	40%	82.2	31.9
50%	130.7	9.4	50%	118.2	13.1	50%	105.9	18.7	50%	93.4	25.1	50%	82.1	32.0
60%	130.4	9.4	60%	117.9	13.2	60%	105.7	18.8	60%	93.1	25.2	60%	81.9	32.1
70%	130.1	9.5	70%	117.7	13.3	70%	105.4	18.9	70%	92.9	25.4	70%	81.7	32.2
80%	129.8	9.6	80%	117.5	13.3	80%	105.2	19.0	80%	92.6	25.5	80%	81.5	32.3
90%	129.6	9.6	90%	117.2	13.4	90%	104.9	19.1	90%	92.4	25.7	90%	81.3	32.4
F	**129.3**	**9.7**	K	**117.0**	**13.5**	P	**104.7**	**19.2**	U	**92.1**	**25.8**	Z	**81.1**	**32.5**

TABLE 1

Field Technician Review Class

Practice Calculations

Answer Key

Calibration of Proctor Mold

✔ Four Inch Mold ______ Six Inch Mold

Mold I. D. #: X
Temperature of Water used for Calibration: 77
Unit Weight of Water: 62.243 lb. / cu. Ft.

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled With Water, and Glass Plate (grams)	Weight of Water to fill Mold (grams)
4439.5	5375.8	936.3

$$\begin{bmatrix}\text{Volume of}\\ \text{Mold}\\ \text{(cu. ft.)}\end{bmatrix} = \frac{\text{Weight of Water to Fill Mold (grams)}}{\begin{bmatrix}\text{Unit Weight}\\ \text{of Water}\\ \text{(lb. / cu. ft.)}\end{bmatrix} \times [453.6\ \text{(grams / lb.)}]}$$

$$= \frac{(\ 936.3\ )}{(\ 62.243\ ) \times (453.6)} = \underline{0.0332}\ \text{cu. Ft.}$$

28233.4248 0.033162821

Remarks:______________________________

Calibration Date:______________________
Test Operator:_________________________
Supervisor and Date:___________________
Calibration Expiration Date:___________

Calibration of Proctor Mold

______Four Inch Mold ✔ Six Inch Mold

Mold I. D. #: Z
Temperature of Water used for Calibration: 71
Unit Weight of Water: 62.293 lb. / cu. Ft.

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled With Water, and Glass Plate (grams)	Weight of Water to fill Mold (grams)
7103.5	9225.1	2121.6

$$\begin{bmatrix}\text{Volume of}\\ \text{Mold}\\ \text{(cu. ft.)}\end{bmatrix} = \frac{\text{Weight of Water to Fill Mold (grams)}}{\begin{bmatrix}\text{Unit Weight}\\ \text{of Water}\\ \text{(lb. / cu. ft.)}\end{bmatrix} \times [453.6\ \text{(grams / lb.)}]}$$

$$= \frac{(\ 2121.6\ )}{(\ 62.293\ ) \times (453.6)} = \underline{0.0751}\ \text{cu. Ft.}$$

28256.1048 0.075084659

Remarks:____

Calibration Date:______________________________
Test Operator:______________________________
Supervisor and Date:______________________________
Calibration Expiration Date:______________________________

CALIBRATION OF DENSITY SAND AND SAND CONE APPARATUS
ARIZ 229
(A Modification of AASHTO T 191)

Date of Calibration:______________ Test Operator:______________________________

I. D. No. of Mold used in calibration: 26-2

Volume of Mold used in calibration: .0754

Identification of Sand: ______________________________

Identification of Sand Cone Apparatus: ______________________________

Trial No.	Wt. of Baseplate And Empty Mold (grams)	Wt. of Baseplate and Mold Filled with Sand (grams)	Wt. of Sand to Fill Mold (grams)
1	6573	9595	3022
2	6573	9597	3024
3	6573	9591	3018

Average Weight of Sand to Fill Mold = 3021 grams

$$\text{Density of Sand, } D_s = \frac{\text{Average Weight of Sand to Fill Mold}}{(453.6 \text{ grams / lb.}) \times (\text{Volume of Mold})}$$

$$= \frac{3021}{(453.6) \times (0.0751)} = \frac{88.7}{} = \text{lb./ft.}^3$$

34.06536 88.68246218

Trial No.	Initial Wt. of Apparatus (grams)	Final Wt. of Apparatus (grams)	Wt. of Sand to Fill Funnel and Baseplate (grams)
1	6242	4723	1519
2	6236	4731	1505
3	6237	4730	1507

Average Weight of Sand to Fill Funnel and Baseplate = 1510 grams

$$\text{Volume of Funnel and Baseplate, } V_{fb} = \frac{\text{Average Weight of Sand to Fill Funnel and Baseplate}}{(453.6 \text{ grams / lb.}) \times (\text{Density of Sand})}$$

$$= \frac{1510}{(453.6) \times (88.7)} = \frac{0.0375}{} = \text{ft.}^3$$

40234.32 0.037530148

Remarks: ______ **$I = D_s \times V_{fb}$** 88.7 X 0.0375 = 3.32625

3.33 lbs.

Supervisor and Date: ______________________________

Calibration Expiration Date: ______________________________

ARIZONA DEPARTMENT OF TRANSPORTATION
SAND CONE DENSITY (ARIZ 230)

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %
		A B					

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO DAY YEAR	TIME (MILITARY TIME)
				:

SAMPLED FROM	LIFT NO.	RDWY	STATION (IF MILEPOST, INPUT DECIMAL)
			+

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER

REMARKS

A. TOTAL WET WEIGHT OF MATERIAL FROM THE HOLE	10.11	LB.
B. WET WEIGHT OF MATERIAL RETAINED ON THE #4 SIEVE	4.88	LB.
C. WET WEIGHT OF MATERIAL PASSING THE #4 SIEVE (A-B)	5.23	LB.
D. MOISTURE OF THE MATERIAL PASSING THE #4 SIEVE	8.6	%
E. MOIST. CORRECTED FOR MATERIAL RETAINED ON THE #4 SIEVE	5.0	%
F. WEIGHT OF SAND & APPARATUS BEFORE FILLING HOLE	14.17	LB.
G. WEIGHT OF SAND & APPARATUS AFTER FILLING HOLE	4.47	LB.
H. WEIGHT OF SAND TO FILL HOLE AND CONE (F-G)	9.70	LB.
I. WEIGHT OF SAND TO FILL CONE AND BASE PLATE	3.33	LB.
J. WEIGHT OF SAND TO FILL HOLE (H-I)	6.37	LB.
K. DENSITY OF SAND	88.7	PCF
L. VOLUME OF HOLE $\left(\frac{J}{K}\right)$	.0718	CF
M. WET DENSITY = $\left(\frac{A}{L}\right)$	140.8	PCF
N. DRY DENSITY = $\left(\frac{M}{100 + E}\right) \times 100$	134.1	PCF
COMPACTION = $\left(\frac{N}{R}\right) \times 100$ OR $\left(\frac{N}{T}\right) \times 100$	100	%
COMPACTION SPECIFICATION	100	%

PROCTOR DENSITY

PROCTOR NUMBER		
PROCTOR METHOD (A, C, D, OR 1)	A	
O. SPECIFIC GRAVITY OF RETAINED #4	2.528	
P. ABSORPTION OF RETAINED #4	0.87	%
Q. OPTIMUM MOISTURE	10.1	%
R. MAXIMUM DRY DENSITY	127.8	PCF

CORRECTION FOR RETAINED #4 (METHOD A OR ONE-POINT ONLY)

S. CORRECTED OPTIMUM MOISTURE	5.7	%
T. CORRECTED MAXIMUM DRY DENSITY	134.7	PCF

a. RETAINED ON #4 = $\left(\frac{B}{A}\right) \times 100$	48	%

IF RET. ON #4 IS MORE THAN 50% (60% IF AB), GO NO FURTHER.

FOR METHOD A OR ONE POINT ONLY

$$E = \frac{[D\ (100 - a)] + a}{100}$$

ONE POINT PROCTOR (ARIZ 232)

b. WEIGHT OF MOLD & SOIL	16.12	LB.
c. WEIGHT OF MOLD	11.63	LB.
d. WEIGHT OF COMPACTED SOIL (b-c)	4.49	LB.
e. VOLUME OF MOLD	.0332	CF
f. WET DENSITY (d / e)	135.2	PCF
g. MOISTURE CONTENT	8.1	%
FAMILY OF CURVES IDENTIFICATION	F & G	30%
Q. OPTIMUM MOISTURE	9.9	%
R. MAXIMUM DRY DENSITY	128.5	PCF

TEST OPERATOR AND DATE

RESIDENT ENGINEER, PROJECT SUPERVISOR, OR LABMAN AND DATE

FOR METHOD A OR ONE POINT ONLY

$$S = \frac{[Q\ (100 - a)] + a}{100}$$

$$T = \frac{[R\ (100 - a)] + [(56.2)\ (a)(O)]}{100}$$